"Down by the Rio" Ecology Curriculum Unit

William A. Siefert

Introduction

What do the Phantom shiner, the New Mexico sharp-tailed grouse, and the Hot springs cotton rat all have in common? According to the New Mexico Department of Game and Fish (1998) these three species are now extinct in New Mexico. Since European settlement of New Mexico, at least ten, and perhaps 11, species and subspecies of native New Mexico fishes have been extirpated from the state or are extinct (Propst). In 1998, the New Mexico Department of Game and Fish listed 117 species of crustaceans, mollusks, fishes, amphibians, reptiles, birds, and mammals as either threatened or endangered species in New Mexico.

Extinction is a normal biological process and global mass extinctions have occurred in Earth's history. Currently, a single species, *Homo sapiens*, is responsible for an unprecedented increase in the rate of extinctions worldwide. In the state of New Mexico, humans have accelerated the rate of extirpation and extinction of species through habitat destruction, degradation of the environment, and the introduction of exotic (non-native) species. Alteration of the landscape and the use of natural resources are a consequence of human settlement. In the arid Southwest, with limited water supplies, sustainable development practices and conservation measures are necessary in order to ensure the health and continuity of a rich natural heritage. Given the amount of ecological knowledge already acquired through scientific research, it is imperative that humankind continue to build upon this base and use the information to best manage and maintain natural systems.

Ecology is the study of the interactions between the living and nonliving components of the environment. The scientific discipline of ecology was named in 1866, but of course, humans have been ecologists as long as our species has existed. In order for humans to compete with other organisms, they had to be aware of the natural cycles of weather, how and where to find food, and to be able to make predictions based on their experiences.

We have accumulated much knowledge about the abiotic and biotic systems of Earth, but there are still relationships that we do not fully understand. As the human population continues to increase we use and consume more of Earth's natural resources and thus can cause large-scale effects in natural systems. Crop monoculturing and overgrazing are increasing the erosion of soil by water and wind, increasing the inflow of sediment into aquatic ecosystems and the input of dust into the atmosphere (Cox). The survival of our species, as well as many other species, depends on how well we understand the consequences of our actions and our willingness to be responsible for our effect on the environment.

The goal of this curriculum unit is to introduce the basic concepts of ecology. Students will learn the concepts by studying local ecosystems of the Middle Rio Grande Valley in New Mexico. The concept of bioregionalism will also be integrated into the curriculum. To possess a bioregional outlook means that in your views and thoughts you are aware of the natural history of the physical and cultural environment of which you are a part. By studying how local culture and natural environment are intertwined, students will discover the relevancy of ecological knowledge and the role it plays in their daily lives.

Academic Setting

This unit is designed for an introductory freshman biology course at the high school level. Cibola High School is a large, middle-class school located in the rapidly growing northwest section of Albuquerque. All 9th graders at Cibola enter school as members of a team in the Freshman Academy. Freshman teams consist of approximately 150 students who share the same biology, English, math, health, and computer technology teachers for the entire year. For the 2000-2001 school year, there were five freshman teams at Cibola. Through weekly meetings and personal conversations, team teachers are better able to monitor student progress, address needs, and develop relationships with their students.

The curriculum unit will be implemented over a two to three-week period. Most students entering high school have a general knowledge of ecology from their own life experiences. The unit will introduce the scientific principles behind the knowledge the students have gained. The classroom activities and lessons will be based on the interactions between the abiotic and biotic resources in the Middle Rio Grande Valley ecosystem. By introducing a bioregionalism component, the information covered will be made more personal to the students. Bioregionalism will draw on a student's cultural knowledge of the local area and its relationship to the physical environment.

Background Information

Given the inherent curiosity and observational abilities of humans, the study of ecology seems like a natural and simplistic consequence of living on Earth. Many ecological concepts appear, on the surface, to be easily explained based on direct experience of a phenomenon by an observer. However, ecological concepts are linked to complex underlying principles based in a variety of disciplines like hydrology, chemistry, and geology. These indirect connections and interactions are what make ecology such an exciting and vibrant scientific endeavor. Even though we humans have made great progress in deciphering and explaining the natural world, there are more secrets and unseen connections that we have yet to discover.

Basic Ecological Concepts

The science of ecology seeks to answer the question of how organisms interact with each other and with the environment. In order to focus ecological research, hierarchical levels of organization are recognized in the natural world. The most inclusive level of organization is the biosphere. This is the thin layer of Earth's surface and its atmosphere that supports life. All living things are part of the biosphere, and human activities can have far-reaching effects on the global system. Two types of environmental factors in the biosphere influence living organisms: abiotic (non-living) and biotic (living). Abiotic factors include all the physical and chemical characteristics of the environment. Important abiotic factors include availability of solar energy, water, precipitation, temperature, oxygen concentration, salinity, pH, and availability of nitrogen. Biotic factors include all of the living things that affect the organism.

The planet's surface can be divided into zones, or biomes, according to physical characteristics like soil conditions, biotic communities, and climate. Each biome has a distinct combination of life forms that is adapted to the particular area. Biomes are usually identified by the dominant plant population present. Some examples of terrestrial biomes are tropical rain forest, grassland, temperate forest, desert, taiga, and tundra. There are many factors that influence the location and characteristics of the different biomes on Earth. The latitude, or the distance from the equator, is an important factor in the determination of what type of biome occurs where.

Biomes are made up of smaller units called ecosystems. An ecosystem can be defined as a unit of the environment made up of living and non-living components that interact and interchange nutrients and energy in a particular place. Ecosystems may be defined on many scales. In New Mexico, the Rio Grande and its riparian (riverside) forest, or bosque, is an ecosystem. In the Sandia Mountains, the foothills region of the western slope could be differentiated as an ecosystem. Also in the Sandias, the spring-fed Cienega Canyon area defines another ecosystem. In ecological research, most study is conducted at the ecosystem level.

All populations (including human) depend upon the indispensable services that the abiotic and biotic components of ecosystems perform. Ecosystems can stabilize severe weather activity, recycle nutrients for continuous use by organisms, and distribute water throughout the biosphere via the hydrologic cycle. Without the biogeochemical pathways maintained by ecosystems there would be no carbon, nitrogen, or phosphorus available for use by living organisms. The hydrologic cycle, driven by the sun, keeps the Earth’s water circulating and can act as a purifier if necessary. These essential services, and many others, operate continuously and often with little notice by the inhabitants who depend upon them.

Ecosystems are dynamic and capable of recovery after disturbances occur within the system. Equilibrium and stability tend to be rare and short-lived. Ecosystems that have stability are able to resist change in the face of external influence (Cox). A desert is an example of a stable ecosystem. Deserts remain stable through years of very different climatic conditions of heat, cold, and drought. A stream ecosystem may be very unstable. Flood and drought conditions in the stream can cause large changes from year to year. Ecosystems can also be resilient, which is the ability to recover from a change or disturbance. Some types of forest ecosystems can recover in a few years following a fire.

Despite the fact that disturbance is natural and plays a role in the dynamics of ecosystems, some human induced disturbances can be catastrophic to the functioning of particular ecosystems. An example of this is the human development and management of the Middle Rio Grande Valley ecosystem (Crawford). Physical changes to the river such as channelization, construction of levees, installation of jettyjacks, and the building of dams has permanently changed the bosque ecosystem (deBuys). These changes were carried out in order to alleviate flooding along the Rio Grande. Reduced flooding saved agricultural fields and houses, but was detrimental to the cottonwood forests that rely on periodic flooding for the establishment of new individuals. Also, the introduction of exotic species, which can out-compete the native species in the bosque, has led to permanent changes in the biotic communities that make up the local riparian ecosystem.

A community in ecology refers to all the interacting organisms living in an ecosystem. A freshwater pond biotic community would include all the different species of turtles, fish, plants, algae, and microorganisms that inhabit the pond. Communities may contain thousands of species and exhibit complex and intricate connections between species. Understanding the interrelationships between species within a community is a key factor in ecosystem management. In a community, organisms are dependent upon one another for survival. The removal or addition of certain species in an ecosystem can have devastating ecological effects.

Biotic communities are comprised of populations of species that live in a particular area at a particular time. A group of organisms that can interbreed and produce fertile offspring constitute a species. The carrying capacity is the number of individuals that a particular environment can support for an indefinite period of time. The carrying capacity of an area is not constant and is dependent on the interactions of many factors in the system. Natural changes in weather patterns, like flood and drought, or human induced problems, like habitat degradation, cause fluctuations in the availability of resources that may alter the number of individuals that can be supported. The abundance or depletion of resources, along with birth and death rates, interact to determine the carrying capacity for a species in a given area.

Basic Ecology of Organisms

All biological activity requires energy. For terrestrial and freshwater aquatic communities the ultimate source of energy is solar radiation. One of the most important abiotic factors that affects the relationships in a community is the flow of energy through the system. Energy moves through a community based on feeding relationships. Initially, through the process of photosynthesis, autotrophs (like green plants) are able to use solar energy to make food. These organisms are called primary producers in the ecosystem. Heterotrophic organisms, or consumers, are those that eat producers for energy. Finally, consumers that break down the dead bodies of plants and animals are called detritovores or decomposers. In any ecosystem, aquatic or terrestrial, there will always be more producers than consumers.

A path that traces what eats what is called a food chain. A food chain usually begins with a producer - a grass plant, for example. At the next level, if an insect consumes the grass, it is called the primary consumer. If the primary consumer is eaten by another organism, a mouse for example, the mouse is a secondary consumer. If an owl eats the mouse, then the owl is called a tertiary consumer. Each level or ‘link’ in this food chain is called a trophic level. The transfer of energy from one trophic level to the next is approximately 10% (90%

being lost or not transferred to the next level). Because of this inefficient transfer of energy, most ecosystems only contain three or four trophic levels. By studying the feeding relationships in an ecosystem it can be shown that many food chains will be connected to each other. If all the food chains are shown together for an ecosystem, a food web is created.

The "niche" of an organism is the role it plays in the community. What an organism eats, what eats it, and what other direct or indirect relationships it has with other organisms and the environment all define the niche. Where an organism lives is called its habitat. Many different species may occupy the same exact habitat, but no two organisms will have exactly the same niche. Organisms may have specific habitat requirements, like a cold, clear, well-oxygenated mountain stream. Others may be more tolerable to a wide range of conditions. The loss and alteration of habitat is the greatest threat to the survival of many species in the world today. The extinction of the New Mexican sharp-tailed grouse was probably due to habitat loss caused by livestock grazing, which eliminated or reduced grasses and forbs, and the conversion of shrubland to agricultural fields (Hubbard).

The complexity of a biotic community depends upon the number and types of interactions between the species present. Predation is an important interaction wherein the predator captures, kills, and consumes another individual, the prey. In this relationship one species benefits, while the other clearly does not. Predation can create a strong selective pressure for both predator and prey species. Through natural selection, the main mechanism of evolution, predation will favor those organisms best suited to capturing and consuming prey. Also, natural selection will favor those prey species that are best able to avoid predation. In this way predation is a natural regulator of population size.

When two species compete for limited resources, neither benefits. Organisms may compete for food, sunlight, nutrients, water, breeding territory, or nest sites. In a situation known as competitive exclusion, one species that is more efficient at obtaining and using a limited resource will eventually eliminate the other competing species. Competitive exclusion can be observed in the Rio Grande bosque with introduced exotic species, like salt cedar *(Tamarix chinensis)* and Russian olive *(Eleagnus angustifolia)*. Once these introduced species were established they grew quickly and out-competed the native vegetation; also the introduced species had fewer natural predators in their new locations compared with indigenous species. The entire bosque plant community has changed with the introduction of non-native species.

When two organisms live in direct physical contact with one another, the relationship is called symbiosis. Lichens that grow on tree trunks and on rocks are one example of a symbiotic relationship. The lichen is actually a fungus and a photosynthetic partner (usually an alga or bacterium) living together as one organism. Neither organism is harmed and their association is mutually beneficial. Parasitism is a relationship where one organism, the parasite, lives off of or in another - the host. Parasites do not always kill the host immediately, although a host may be severely weakened by the activity of the invader. Mistletoe is a parasitic plant that can attack some tree species causing limb damage and loss of nutrients.

Biodiversity

Diversity in biology can be observed at different levels. At the molecular level, there is genetic diversity in the makeup of a species. Long strands of DNA (deoxyribonucleic acid) make genes in living organisms. Alternative forms of a gene are called alleles. Within a population, there can be a variety of alleles coding for the same particular trait. It is this genetic diversity that creates different skin or hair tones, different blood types, and the many other variations of inherited traits.

At the species level, biodiversity recognizes the richness and variety of the differences within and between populations of living organisms. A simple measure of biodiversity is to count the number of different species that live in a given area. In the biosphere, estimates of biodiversity range from a minimum of 2 million species to as many as 30 million different life forms. New Mexico, with its varied landscapes and climate, has 151 species of native mammals. This is second only to California in non-tropical North America which has 162 mammal species (Frey and Yates). Since records were kept starting in 1820, 478 species (plus 474 subspecies) of native birds have been confirmed as occurring naturally in New Mexico (Hubbard). New Mexico is fortunate to have such a wealth of biological diversity.

The variety of communities and ecosystems can also be studied. Ecosystem diversity measures all the habitats, biological communities, and ecological processes that occur between individual ecosystems. If an ecosystem is highly diverse, this will lead to greater biodiversity in the entire system. A natural area, which provides more habitats, will create more opportunities for species to adapt and utilize a wider variety of available resources. In New Mexico, the amount of forest ecosystem diversity is quite great even though forests account for only 10.7% of the landscape. For the entire Southwestern United States, 135 different forest types or vegetation associations are recognized; in New Mexico 108 of these forest types have been documented (Moir and Fletcher).

Ecology of the Middle Rio Grande Valley

The Rio Grande headwaters begin in southern Colorado in the San Juan Mountains. From there the Rio Grande flows approximately 1,900 miles to the Gulf of Mexico near Brownsville, Texas. The Middle Rio Grande Valley, the focus of this unit, extends from Cochiti Dam downstream 160 miles to Elephant Butte Reservoir in central New Mexico. The drainage basin for the Middle Rio Grande is 24,760 sq. mi. Form north to south, the Middle Rio Grande flows through three major biotic communities: Great Basin Grassland, Semidesert Grassland, and Chihuahuan Desertscrub (Brown and Lowe, cited in Crawford).

The valley contains nearly 40% of New Mexico’s population as it passes through four counties and six pueblos. Most of this human population lives in an urban setting, but rural and agricultural areas are found throughout the valley. Along the entire Rio Grande, the water is tightly controlled and monitored by various governmental agencies. The water that flows through the valley is managed mainly by the Middle Rio Grande Conservancy District, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers. Individual citizens, municipalities, pueblos, and wildlife refuges also own water rights.

Before human habitation of the Middle Rio Grande Valley, the river was a sinuous and braided watercourse that tended to meander freely across its floodplain. During high runoff or heavy snow melt new channels would be formed, leaving behind wetlands, ponds, and isolated cottonwood-willow communities. The native bosque ecosystem relied on this periodic flooding and meandering nature of the river for its continuity and survival. Cottonwood seeds require bare and moist soil for germination. As the river flooded, banks were scoured clean, providing open soil, access to sunlight, and adequate moisture for the establishment of new seedlings. The flooding also delivered sediment and soil nutrients to inundated areas, which helped to maintain the rich and complex bosque ecosystem.

Human use of the valley has occurred since 11,000 year ago. Early hunters and gatherers appeared after the last ice age to hunt now-extinct mammoths, tapirs, and sloths in the valley and surrounding uplands. These ancient people were nomadic with small populations and had minimal impact on the bosque. Around 2,000 years ago, descendants of the PaleoIndians settled in the valley, built communities and began farming in the floodplain. The settlers, later called Pueblo Indians by the Spanish, utilized high-flow floodwater irrigation techniques and small-scale clearing of vegetation which had little effect on the river and its bosque.

In the 1500s, the Spanish arrived and began to settle in the valley. The Spanish brought livestock to the area, cleared land for crops, and introduced more intensive systems of irrigation. These gravity flow irrigation systems used canals and acequias (irrigation ditches) to divert river water to fields. The Spanish settlement continued through the 17^{th} and 18^{th} centuries by land grants from the Spanish government. The increased agricultural use and livestock herding had a great impact on the riparian ecosystem in the valley, mostly from vegetation loss by clearing and alteration of the stream flow through irrigation. During this time period, the river still behaved naturally according to the variations in climatic cycles. Episodes of drought and flooding were not uncommon, and these acted to maintain the integrity of the bosque ecosystem.

Throughout the 1800s increasing immigration of Anglo-Americans into the valley led to greater alterations and impacts in the riparian ecosystem. In the floodplains, more land was converted for agricultural use; in the drainage basin uplands cattle grazing, mining, and logging were intensified. These soil erosive activities added sediment to the river and, when combined with reduced water flows from irrigation diversions, caused the riverbed to aggrade (raise). This changed the hydrology of the river and its aquifer, forcing groundwater to rise and waterlog floodplain fields. As the waterlogged fields dried, salts would leach to the surface, not only affecting crops, but also disrupting the germination and growth of riparian vegetation.

As the hydrologic problems in the valley grew worse it was apparent that solutions were needed. It was in the early 20^{th} century that management and regulation of the Rio Grande began. In 1925, the Middle Rio Grande Conservancy District (MRGCD) was established by the New Mexico state legislature to solve the problems concerning flooding, irrigation, and drainage. Levees were built to contain the river’s flooding and reduce its tendency to meander. El Vado Dam was constructed on the Rio Chama for water storage and flood control. To supply irrigation water, diversion dams were placed in the river in addition to the construction of 250 miles of irrigation ditches and the rehabilitation of 400 miles of old acequias. To alleviate waterlogging in the floodplain, the MRGCD built a system of drainage canals, which essentially dried up most of the valley’s wetlands. These initial projects were completed by 1936.

After a great flood in 1941, the MRGCD added even more flood control measures to the Rio Grande and its tributaries. Four dams were built at Abiquiu, Jemez Canyon, Galisteo, and Cochiti. The river was straightened and channelized in places. Over 100,000 Kellner jetty jacks were installed along the river and between the levees to stabilize the bank and trap debris. Jetty jacks were also placed in the river channel to stop sediment and establish new banks that helped straighten and control the flow of water in the river.

The water control and management projects were successful at meeting their goals of stabilizing the hydrologic regime of the Middle Rio Grande. These accomplishments favored agricultural development and also allowed the urbanization of the valley to proceed. The changes did improve the livelihoods of many human inhabitants of the valley at the expense of some non-human populations. Most of the changes in the native fish community of the river occurred because of human disturbances to the aquatic habitat. The combined effects of river channelization, flow regulation, and pollution negatively impact habitats and the species that rely on them for survival.

In addition to the physical alteration of the Rio Grande, the introduction of exotic species has also had a devastating effect on the native communities in the bosque. European starlings, house sparrows, feral cats and dogs, Siberian elm and 30 species of non-native fishes are examples of organisms that have displaced much of the native flora and fauna in the Middle valley. Two notorious non-natives, the salt cedar and Russian olive, were originally planted for erosion control purposes along watercourses throughout central New Mexico. These exotics proliferate quickly and take over areas that would normally be occupied by cottonwood-willow communities. In the next 50 years, without plans to control their growth, the introduced plants will become the dominant species in the bosque. It would be impossible to remove the introduced species, therefore the continued study of these communities is necessary to develop plans to control ecological problems they create.

The riparian ecosystem is still a source of great biodiversity in New Mexico. The cottonwood-willow community supports varied bird populations as well as provides habitat for seasonal neotropical migrants. The aquatic habitat is home to nine different amphibians, over 30 species of reptiles, and many fish species. Over 60 mammals, including 11 bat species, utilize the bosque and its resources. By number, the largest community in the bosque is the arthropods, which are an important link in the proper functioning of ecosystem services like energy transfer and nutrient recycling. The Rio Grande and its bosque are also important to humans. It is this vital river system that gives life to our endeavors in the valley and provides the basis for many intangible spiritual connections to the natural world.

Currently there are a variety of research and restoration projects underway concerning the Middle Rio Grande ecosystem. In 1993, The Middle Rio Grande Biological Interagency Team, consisting of members from the University of New Mexico, U.S. Fish and Wildlife, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and New Mexico State University produced the "Middle Rio Grande Ecosystem: Bosque Biological Management Plan." This plan was developed to provide recommendations for the management of the middle valley in order to maintain the health of the system. The extensive document explains past history, current use, and future prospects for the riparian ecosystem. The 21 recommendations and management strategies of the plan offer specific changes to existing practices to increase the biological quality of the ecosystem.

The City of Albuquerque Open Space Division has undertaken many habitat restoration and protection projects located in the Rio Grande Valley State Park. The division has constructed wetlands, planted thousands of native trees and shrubs, and periodically removes vegetative fuel from the bosque. A long-term study, called the Albuquerque Overbank Project, involves clearing vegetation on the bank then lowering that bank to allow flooding and the subsequent establishment of native woody species at the site following springtime floods. The success of restorative activities in the bosque depends on the efforts of governmental agencies and especially, the continued education of the public as to the importance of preserving a healthy riparian ecosystem.

The City has also begun a study dealing with the restoration of the Rio Grande silvery minnow, which is federally listed as endangered. The silvery minnow formerly inhabited 1,000 miles of the Rio Grande from the Middle valley to the Gulf of Mexico. Due to habitat loss and modification of the natural flow of the river, the minnow is now present in only 5% of its original range. In the spring of 2000, the city provided $100,000 for a captive-breeding program known as the "Rio Grande Silvery Minnow Recovery Plan." Minnows were captured in the wild and brought to the Albuquerque Bio-Park where they were propagated. The project is studying the life history of the minnow, habitat requirements regarding water velocity and water quality, and the practical problems dealing with reintroducing the minnow to its historic range.

Bioregionalism

Bioregionalism is a concept or way of thinking that requires a person to be aware of the immediate physical and cultural resources, including abundance and limitations, of any given place. Bioregionalism calls for human society to be more closely related to nature, and to be more conscious of its locale, or region of life-place (Corcoran and Sievers). Ecological knowledge and an appreciation of the local environment create the sense of place that is necessary to show the interdependence and interconnectedness upon which a bioregional perspective is built. Cultural knowledge of place is important for sustaining communities and can play a role in ecosystem management.

Any discussion of North American bioregionalism must credit Native Americans as inspiration for living fully and well within the limits of a place (Corcoran and Sievers). The land of New Mexico has a long and varied history of Native American cultural settlement and development. It is estimated that in the year 1300, the population of the Middle Rio Grande Valley was 15,000. The native communities used irrigation water from the river to grow crops like maize and beans. The people lived in mud homes, some two stories high. Their culture was well developed and had deep connections to the natural landscape.

The early Spanish settlers relied on sustainable use practices when they set up their farms and communities in Northern and Central New Mexico (Pena). Settlements were established around the acequia or the gravity ditch system. Diverted water was used to irrigate fields, and unused water was returned to the river. Each landowner received a certain amount of water for irrigation and was also partly responsible for the maintenance of the system. The acequia system was a democratic unit that kept communities small and connected through a common purpose. The settlements also viewed the watershed uplands and woodlands as property belonging to all the members of the community. The acequias and common lands served as habitat for wildlife and nurtured a conservation ethic in those dependent on the proper functioning of the entire ecosystem.

In what is now the United States, it is claimed that the Middle Rio Grande Valley holds the record for the longest continuous human habitation. As present residents of the same area, we should feel obligated to maintain such an awesome legacy. Of course, our modern society and culture may seem completely alien to those that occurred historically in the valley, but we are still connected to the same river and its surrounding ecosystem. Our stewardship of a stressed river system is now imperative. Education based on the ecology of the bosque is a necessary foundation for building a bioregional ethic. As knowledge of the intricacies and importance of the riparian ecosystem increases this may lead to changes in attitudes and possible life-style modifications which will benefit the system.

Implementation

New Mexico State Standards

This unit is designed to meet the following New Mexico State Standards for students in grades 9-12.

Content Standard 11: Life Science Students will know and understand the synergy among organisms and the environments of organisms.

B. B. Students will describe the impact on individual organisms by atoms and molecules among the living and nonliving components of the biosphere.
C. D. Students will predict changes in a population based on knowledge of the population's characteristics.
D. E. Students will apply the concepts of competition and cooperation to changes in an ecosystem.
E. F. Students will predict the impact humans might have on species and environmental systems.
F. G. Students will analyze the impact of resource depletion in overpopulated areas on social and cultural norms.

In addition to the following activities, students will be assigned textbook reading, review questions, and vocabulary as homework. These assignments will serve as the foundation for teacher lectures and class discussions pertaining to ecological concepts.

Vocabulary list

abiotic	detritivore	irrigation
acequia	ecology	migration
biogeochemical cycle	ecosystem	native species
biodiversity	exotic species	niche
biome	extinction	nitrogen cycle
biotic	extirpation	omnivore
bosque	food chain	parasite
carbon cycle	food web	population
carnivore	ground water	predator
community	habitat	prey
competition	herbivore	producer
competitive exclusion	host	riparian

consumer	hydrologic cycle	species
decomposer	introduced species	symbiosis
		trophic level

Activity #1 Introductory Questionnaire

Bosque Background Knowledge Inventory

This written-response questionnaire is designed to assess the amount of background knowledge students possess concerning general ecological concepts of the Rio Grande bosque ecosystem. An interview can be used in place of written answers for those students with limited English proficiency or with special needs.

The questionnaire will be graded and used to generate discussion and an introduction to the material to be covered in the unit.

Directions: Write brief answers to the following using complete sentences:

1. The bosque is considered an ecosystem.
    a. Explain what is meant by "ecosystem."
    b. Name two additional ecosystems, besides the bosque, found in New Mexico.
2. Explain what "biodiversity" means.
3. People say, "We should kill all the ants. They are a nuisance and cause damage in our homes." Explain, using scientific reasoning, why killing off all the ants is not a good idea.
4. Where does Albuquerque’s drinking water come from?
5. Where does the water in the toilet go after you flush?
6. Through development of cities and the use of natural resources, humans change the environment in which they live. Describe one human-caused change in the bosque that has affected the bosque ecosystem.

Activity #2 Random Sampling of Ecological Factors in a Square Meter

Objectives: Students will:

- Identify the biotic and abiotic factors in a square meter plot in the bosque
- Conduct random sampling of plant populations
- Draw and label the factors in the sample plot
- NM State Standards: 11 B, 11 F

Background: After classroom discussion of habitat, niche, and general bosque ecosystem interactions, students will travel to an outdoor site and complete a sampling activity. The scientific method of inquiry will be introduced through random sampling, data collection, and drawing conclusions.

Procedure: In groups of two, students will randomly select and mark a one meter square area in the bosque. The group will make two general sketches of the plot, one showing the vertical structure of the vegetation overstory marked off in two meter increments, and a second showing the horizontal arrangement of ecological factors in the plot. The group will also make a data card for each species present. The card shall include a drawing, name, description, where found, number of individuals found in plot, and any other observations.

Assessment: Student sketches and data cards will be checked for accuracy and completeness. The following homework questions will be assigned and graded: 1) Describe three ways in which the biotic factors in your plot are dependent on the abiotic factors. 2) Explain how the autotrophs, heterotrophs, and decomposers are connected in the maintenance of an ecosystem. 3) Describe one other ecosystem found in the bosque.

Activity #3 Bosque Food Web

Objectives: Students will:

- Identify the feeding relationships in the bosque ecosystem
- NM State Standards: 11 B, 11 D, 11 F

Background: After discussion of the flow of energy through trophic levels, students will be given descriptive niche cards of bosque plants and animals. The cards will contain the feeding information for a variety of animals found in the bosque. The students can read aloud the information for their organism. This is also an opportunity for students to tell any personal experiences they have had with wildlife in the bosque or other natural areas.

Procedure: Students will use string in the classroom to make the connections based on who eats whom from their niche cards. A disruption in a food chain link will be introduced to show how individuals are affected by others in the community.

Assessment: After constructing and observing the food web in class students will be assigned the following questions: 1) What happened when one member of the food web was eliminated? 2) What role do the unseen organisms play in the food web? 3) Beginning with the sun, trace the flow of energy though one food chain in the bosque food web.

Activity #4 Investigating the Biogeochemical Cycles

Objectives: Students will:

- Draw, label, and explain the biogeochemical cycles for water and carbon
- Investigate the carbon-oxygen cycle in a closed system
- Set up, observe, and collect data from a laboratory experiment
- NM State Standards: 11 B, 11 F

Background: In the first part of this activity, a class discussion will cover the general aspects of the water and carbon cycles. A detailed description and diagram of the nitrogen cycle will be given as a guide for the students.

In the second part of the activity, students will set up an experiment using a fresh water plant, *Elodea*, pond snails, and the chemical indicator bromothymol blue. This experiment is designed to show the carbon-oxygen cycle in a closed system. Students will need a brief introduction to the process of photosynthesis and cellular respiration. During photosynthesis, green plants use carbon dioxide as a source of carbon to produce carbohydrates and give off oxygen as a byproduct. During cellular respiration, organisms use oxygen and give off carbon dioxide as a byproduct. In water, carbon dioxide forms a weak acid - carbonic acid. The chemical indicator, bromothymol blue, turns green or yellow in the presence of an acid.

Procedure: For the first part, students will be given information in text on the water and carbon cycles. Their task is to draw and label the two cycles using specific organisms and abiotic factors found in the bosque.

For the second activity, students will need eight test tubes per group, two sprigs of *Elodea*, and two pond snails. Add four drops of bromothymol blue to each test tube. The eight test tubes will be divided into two sets, one exposed to light, the other kept in a dark place. Each set has a control tube with no organisms, a tube containing only a snail, a tube containing only a sprig of *Elodea*, and a tube with a snail and *Elodea* together. After twenty-four hours, observe any color changes in both sets of test tubes. Record these observations in a data table, showing initial and final color of the liquid in the tubes. Follow all safety requirements for handling live organisms and chemical compounds.

Assessment: In the first activity, student diagrams will be checked for clarity, correctness, and depth of explanation. Students will be assigned the following questions: 1) Explain how the water and carbon cycles have been influenced by human activity in the bosque. 2) Explain the importance of ecosystems in the biogeochemical cycles.

For the second activity, each student group will turn in a lab report which includes an explanation of the activity, the lab set-up, and a completed data table. Also, these questions will be assigned: 1) Explain, in detail, what caused any color changes in the test tubes, 2) Explain the purpose of each of the tubes that contained only bromothymol blue, only a snail, and only *Elodea.* 3) Explain how the process of cellular respiration and photosynthesis are dependent on each other.

Activity #5 Effect of Introduced Species on Native Populations (based on an activity found in the draft version of "Discover a Watershed: The Rio Grande/Rio Bravo" Educator's Guide).

Objectives: Students will:

- Identify exotic (non-native) invasive species form native species in the bosque
- Recognize the impact that invasive species have on natives
- NM State Standards: 11D, 11 E, 11 F

Background: Students will learn about the introduced species and the native bosque species in a class discussion. Live specimens (of the exotics) will be brought into the classroom. To show the "take-over" effect of invasive species a game similar to musical chairs will be played. Students will be either an invasive salt cedar or a native plant. The game is arranged to have salt cedar continually win and replace the native species.

Procedure: Arrange a row of chairs in a meandering fashion to show the form of the river. Students will be designated as either an invasive salt cedar or a native cottonwood. Red and green paper strips or pictures of the trees could be used. As music plays, students circle the seats. When the music stops the students must find a chair and successfully "plant" themselves. To start the next round, students leave their strip of paper on the chair and circle again. To show the advantage some invasive species have, salt cedar students are allowed to circle closely around the chairs while native plants must circle five feet away. If a native plant student lands on an invasive plant chair, that student will become an invasive and receive an appropriately colored paper strip. Continue to play until most (or all) of the chairs are taken over by invasive species.

Assessment: By participating in the game, students will be made aware of the devastating effect invasive species have on native populations. Class discussions to follow could include these questions: 1) Explain the problems that invasive species create in ecosystems. 2) Explain how invasive species are able to take over areas and out compete native species. 3) Name other invasive organisms found in the Middle Rio Grande Valley.

Activity #6 Research Project and Presentation

Objectives: Students will:

- Conduct independent research
- Create a power point slide show to be presented in class
- NM State Standards: 11 D, 11 F, 11 G

Background and Procedure: This long-term project will be assigned at the start of the unit and will be presented at the conclusion of the unit. After previous class discussions, a trip to the bosque, and viewing the video *Rio Grande: New Mexico's Treasure*, produced by the Middle Rio Grande Conservancy District, students will research a topic chosen from a list provided by the teacher. The students will gather and arrange the information on paper before putting the slide presentation together in their computer technology class. Sample topics include: silvery minnow, introduced species, restoration in the bosque, environmental problems in the bosque, human uses of the bosque, and human history in the Middle Rio Grande Valley.

Assessment: Students will have weekly topic check-ups to ensure progress and feasibility of their research topic. They will need to produce a minimum number of slides and turn in an outline of their presentation. The in-class presentation will be evaluated with a standard rubric for content, clarity, and completeness by the teacher and by fellow students.

Other Possible Activities

- Arrange a guest speaker from the U.S. Bureau of Reclamation or Army Corps of Engineers to explain the management practices, past and present, of the Rio Grande watershed.
- Arrange a guest speaker from the Albuquerque Open Space Division or New Mexico State Parks to explain the need and

progress of local restoration projects in the bosque.

- Plan a second field trip to the bosque in a different season than the first trip to observe the changes that occur in plants and animals over time.
- Coordinate a class community project to "adopt" a section of the bosque in conjunction with the Open Space Division or State Park activities to remove trash from the bosque or plant native species in a restoration area.

References Cited

Corcoran, P.B., and E. Sievers. "Reconceptualizing Environmental Education: Five Possibilities." *Journal of Environmental Education* 25. 1994: 4-8.

Cox, G. W. *Conservation Ecology*. Dubuque, IA: William C. Brown, 1993.

Crawford, C. S., A. C. Cully, R. Leutheusen, M. S. Sifuentes, L.H. White, and J. P. Wilber. *Middle Rio Grande Ecosystem: Bosque Biological Management Plan.* Albuquerque, NM: US Fish and Wildlife Services, District 2, 1993.

DeBuys, W. "One Hundred Years of Change in the Bosque of the Middle Rio Grande." *A Presentation to the Middle Rio Grande Consortium's Fall Conference, November 5, 1999.* 6 June 2001.

Frey, J. K., and T. L. Yates. "Mammalian Diversity in New Mexico." *New Mexico Journal of Science* 36. 1996: 4-37.

Hubbard, J. P. "The Recent Avifauna of New Mexico." *New Mexico Journal of Science* 36. 1996: 38-59.

Moir, W. H., and R. Fletcher. "Forest Diversity in New Mexico." *New Mexico Journal of Science* 36. 1996: 232-254.

New Mexico Department of Game and Fish. *Handbook of Species Endangered in New Mexico.* Santa Fe, NM: Department of Game and Fish, 1998.

Pena, D. G. "Cultural Landscapes and Biodiversity: The Ethnoecology of an Upper Rio Grande Watershed Commons." *La Gente: Hispano History and Life in Colorado,* ed. Vincent C de Baca. Denver, CO: Colorado Historical Society, 1998: 241-271.

Probst, D. L. *Threatened and Endangered Fishes of New Mexico.* Santa Fe, NM: New Mexico Department of Game and Fish, 1999.

Reading List for Students

Audubon Field Guide Series, each volume by a different author

> These very informative and all-color photographic field guides provide detailed life histories and comments about the organisms of North America. The series titles include: *Birds, Butterflies, Insects and Spiders, Mammals, Reptiles and Amphibians, North American Fishes,Trees and Wildflowers.*

Eyewitness Books Ecology, by Steve Pollock, 1993.

> Describes basic ecological concepts for terrestrial and aquatic systems using a variety of photographs and diagrams.

Eyewitness Books Pond & River, by Steve Parker, 1988.

> Describes the wide variety of plants and animals found in freshwater throughout the year. Natural histories and living conditions are given for creatures dwelling at the edge of the water and under its surface.

Meet the Wild Southwest, by Susan J. Tweit, 1995.

> A kid-friendly guide to the natural wonders of the Southwest United States. Includes "You can do it" activities which serve as hands-on learning experiences for the concepts contained in the book.

The Great Southwest Nature Factbook, by Susan J. Tweit, 1992.

> A very good overall reference in narrative style for ecosystems, animals, plants, and human history in the Southwest.

Reading List for Teachers

Albuquerque's Environmental Story: Educating for a Sustainable Community, by Hy and Joan Rosner, 1996.

> An indispensable resource for information on geological, human, and biological history of the entire Albuquerque area. Activities included for learning about the natural and

man-made environments of Albuquerque. Available on line at http://www.cabq.gov/aes/

Bosque Education Guide, coordinators: Mary Stuever and Letitia Morris, 1995.

A great source for information and environmental education activities to accompany studying the Middle Rio Grande bosque ecosystem.

Flowering Plants of New Mexico, by R. D. Ivey, 1995.

An extensive volume of line drawings of the plants of New Mexico.

Modern Biology, by Towle, 1999.

Introductory textbook for high school biology.

New Mexico's Natural Heritage: Biological Diversity in the Land of Enchantment, New Mexico Journal of Science, E. A. Herrera, L. F. Huenneke, eds. 1996.

This volume contains fourteen authoritative articles covering the natural resources of New Mexico.

Snakes, Lizards, Turtles, Frogs, Toads & Salamanders of New Mexico, by M. A. Williamson, P.W. Hyder, J. S. Applegarth, 1994.

A field guide loaded with information, distribution maps, color photos, and a dichotomous key for accurate identification of reptiles and amphibians in New Mexico.

The Sibley Guide to Birds, by D. A. Sibley, 2000.

This field guide has superb color illustrations, descriptions, and range maps for all the bird species of North America.

Internet Web Sites

A preliminary search on the internet using the key terms "Middle Rio Grande Conservancy" yielded over 2,000 web sites. Listed here are three sites devoted to the Rio Grande. The reader is encouraged to perform more extensive web site searching.

Amigos Bravos
http://www.amigosbravos.org/
A New Mexico river advocacy group with a mission to preserve the ecological and cultural heritage of the Rio Grande watershed.

Rio Grande/Rio Bravo Basin Coalition
http://www.rioweb.org
The coalition supports local communities toward restoring and sustaining the natural environment and the social environment of the Rio Grande/Rio Bravo Basin.

Rio Grande Restoration
http://www.riogranderestoration.org
A non-profit organization dedicated to restoring the Rio Grande ecosystem.